International Collaboration On Local Sand Transport Processes And Morphological Evolution

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LONG-TERM GOAL

To develop and enhance international collaboration in the area of coastal sediment transport processes.

SCIENTIFIC OBJECTIVES

The primary objectives of our collaboration are to further the theoretical and experimental investigations of the smaller-scale physical processes which must be incorporated in the development of a local model for sand transport and morphological evolution in coastal regions, including bedform prediction, local boundary layer hydrodynamics and a description of sediment dynamics covering the region from the immobile seabed to the overlying dilute suspension, incorporating both bedload and suspended load modes of sand transport.

APPROACH

We are integrating our various individual skills through a co-ordinated program of process evaluation, development, and validation. Process and model evaluation/development is being accomplished by building upon existing theories and models and by utilizing the comprehensive data sets that have already been obtained in large scale laboratories and field experiments (e.g. SANDY DUCK, the EC MAST programme) or have been undertaken with NICOP assistance (SISTEX99 in Hannover, Germany, Percolation experiments in Brisbane, and the Novosibirsk field campaign).

WORK IN PROGRESS

A. **SISTEX99** (**S**mall-scale **I**nternational **S**ediment **T**ransport **Ex**periments 19**99**): in the Large Wave Flume in Hannover, Germany (TMR-framework (EU) and NICOP). Univeristies of Twente (UT), East Anglia (UEA), Florida (UF) and Santa Barbara, California (UCSB) in collaboration with Franzius Institute and the Large Wave Flume of the University of Hannover, Delft University of Technology, Proudman Oceanographic Laboratory, Albatros Flow Research, and University of Utrecht. The cross-shore morphological development is controlled by the complex mechanisms of sediment transport processes close to the seabed. To improve sediment transport modeling, information is needed about bedform-behavior and near-bed sediment transport processes, especially under controlled full-scale conditions. Therefore, experiments were carried out in the Large Wave Flume of the University of Hannover (length of the flume: 300 m, width: 5 m and depth: 7 m). The test section consisted of a 45 m long horizontal sand bed with uniform sand (median grain diameter: 240 microns)(fig 1). Wave conditions varied from regular to groupy, random and bi-model random waves both in the rippled bed and in the sheet flow regime. Due to the collaboration between the different partners, who all brought their own instruments, a very complete data set of net transport rates, bedform characteristics and near-bed flow velocities and sediment concentrations was obtained.

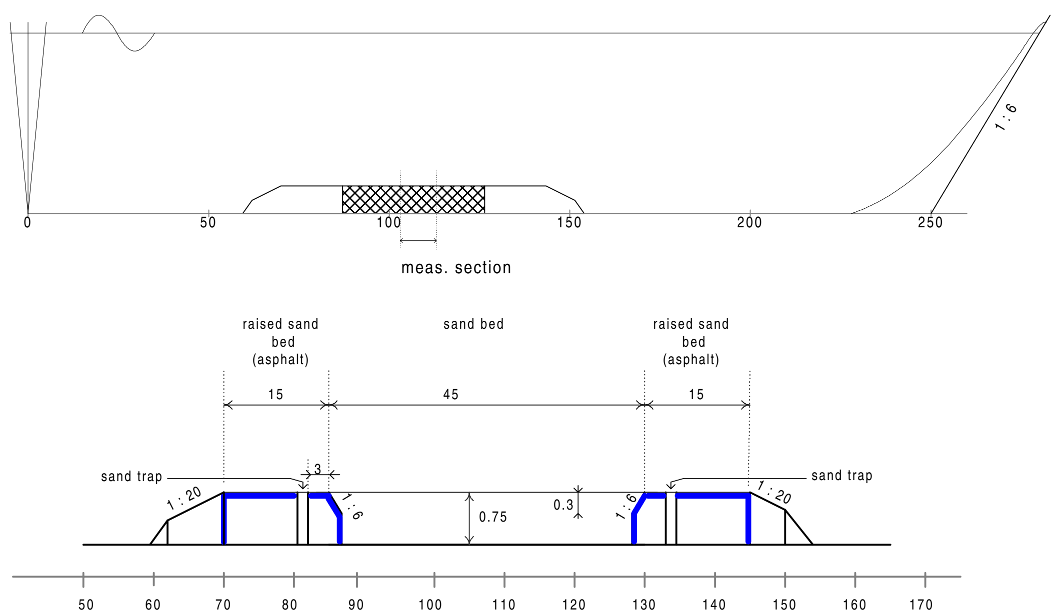

Figure 1: The Large Wave Flume and the sand bed test section at the Franzius Institute, Hannover

B. PERCOLATION EXPERIMENTS**:** The influence of percolation on suspended sediment concentrations and the growth of bed forms; University of Brisbane in collaboration with students from UEA, DUT and the University of Paris. Experimental work is being conducted in a purpose-built flume at the University of Queensland to quantify the stabilising effect on sediment particles of infiltration and the competing destabilising effect of increased bed shear stresses generated by the same infiltration. The flume is 29m long, 78cm deep, and 86cm wide with a sand bed 3.47m long. A hose allows water to drain through the sand bed. The transport parameters which are being monitored include initiation of motion, ripple height, ripple length, ripple pattern, spontaneous ripple formation, suspended sediment concentrations and net sediment transport rate. A wave maker has been constructed and installed which is capable of generating very clean, regular waves by having the capability of tilting the flap at an adjustable rate simultaneously with the back and forth motion. A false bottom and a sand bed through which water can be withdrawn at controlled rates have also been designed and installed in the flume.

C. RUSSIAN FIELD EXPERIMENTS: Vertical sorting of suspended sediment particles by size, density and shape in the nearshore zone, Institute for Water and Environmental Problems, Barnaul, Russia. The field experiments were carried out on two sandy beaches, one barred and one unbarred on the Novosibirsk Reservoir in Russia. D50 for both varied from 0.30-0.34 mm near the shoreline to 0.16-0.18 mm at a depth of 1.8 m and were a mixture of well-rolled (up to 28%), semi-rolled and angular grains. Heavy minerals (density >2.8 kg/l) made up ~13% of the sand near the shoreline and ~3% at a depth of 1.8 m. Seven frames were arranged along the barred beach profile at depths between 0.5 and 1.8 m and 3 tripods were positioned at the non-barred beach. Each was equipped with wave wires, a mean-flow sensor, and sets of the sediment traps. In addition, a sled with three EMCMs and a transverse-suction pump sampler was moved along the transect.

RESULTS

A. Figure 2 shows an example of time-averaged sediment concentration profiles, measured under monochromatic waves in the sheet flow regime, using the Transverse Suction system using in the SISTEX99 experiments. The figure shows that the time-averaged suspended sediment concentration profile $c_m(z)$ follows a power-law distribution:

$$c_m(z) = c_a \left(\frac{z_a}{z} \right)^{\alpha}$$

The power α varies between 2.0 and 2.4, which is very similar to values of α found from time-averaged concentration profiles measured in an oscillating water tunnel ($\alpha = 2.0 \pm 0.1$).

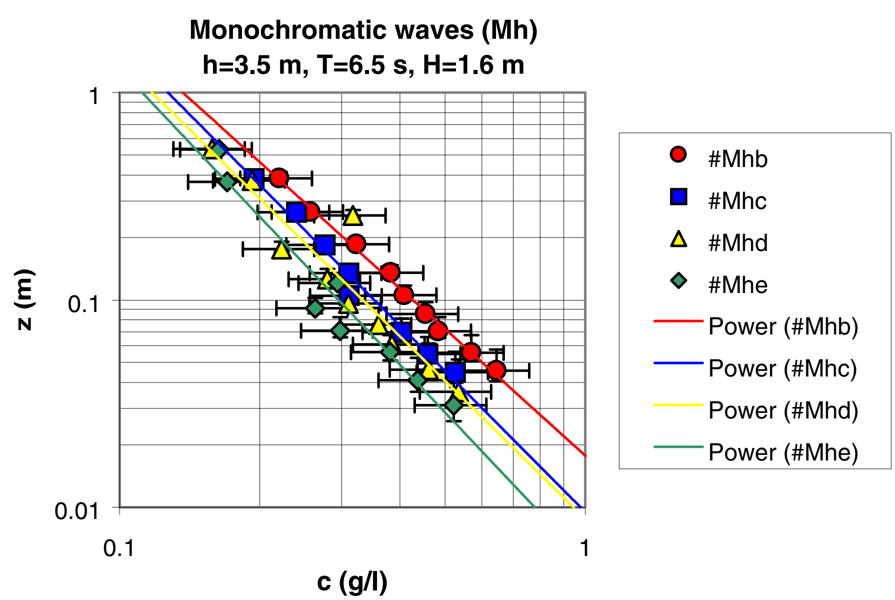

Figure 2: Time-averaged suspended sediment concentration, measured by Transverse Suction

A new instrument has been built to measure sand transport in the bedload layer (a few mm). It consists of two small Conductivity Concentration Meters (CCMs), a stepper motor to move the CCMs up and down, and an encoder that reads the vertical distance. The CCM-system was installed in a cannister that was buried under the sand bed. Concentration measurements are based on the conductivity of the sand water mixture. A cross-correlation technique will be used to determine the grain velocities.

Measurements of suspended sediment concentration, pressure and near bed flow velocities were also made using a) the UF Littoral Sedimentation Process System (previously used at Sandy Duck), and b) the TRIDISMA prototype instrument. This combination of instrumentation has allowed the processes of sand re-suspension over sand beds of well known characteristics to be examined in considerable detail. Regular (monochromatic), groupy and real (Sandy Duck) waves were run repeatedly and excellent measurements of suspension (figure 3) and bedforms obtained.

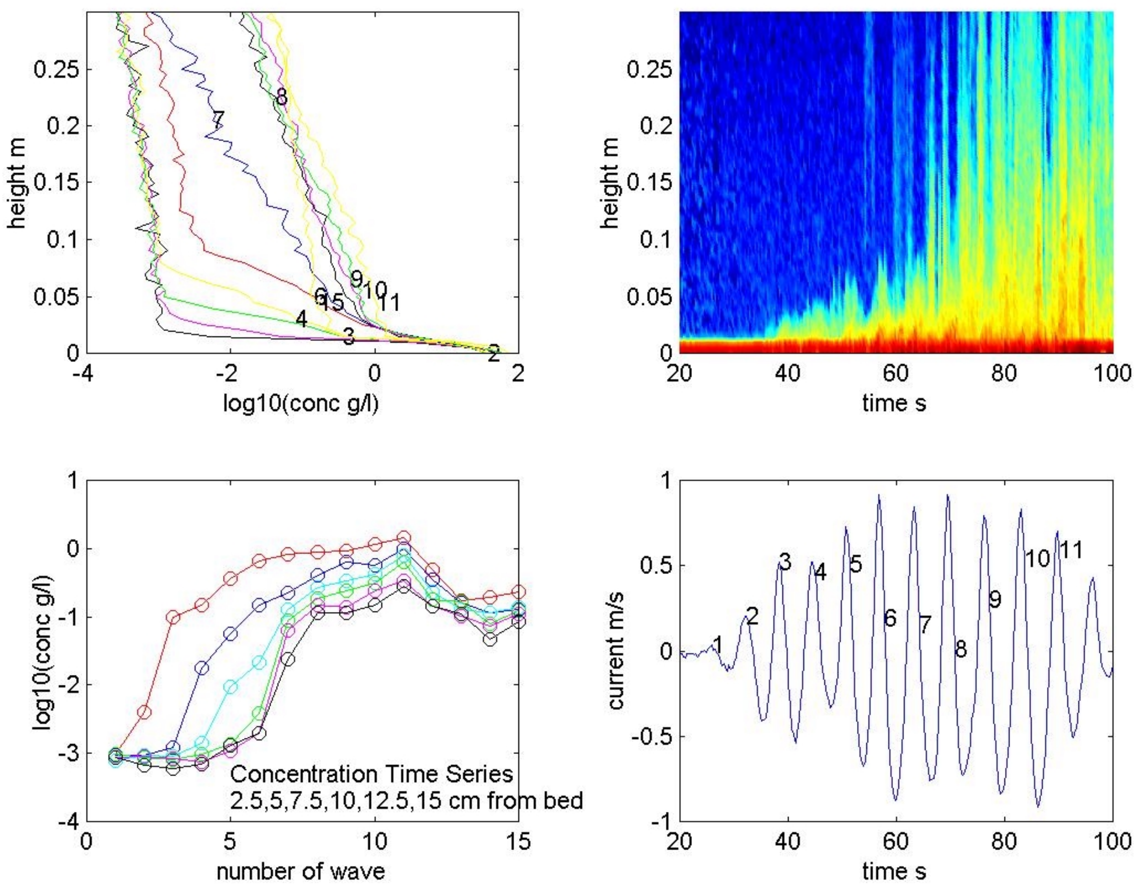

Figure 3 (from top right clockwise) a) suspended sand concentration (red > 0.1 g/l, blue < 0.0001 g/l), b) current speeds due to wave group, c) wave-average concentration time series, d) wave-average concentration profiles

B. Using UEA's Acoustic Backscatter System (ABS) to measure sediment concentrations within 0.01 m of the sand bed, a clear effect of seepage into the seabed was obtained. Figure 4 shows changes in the near-bed concentration over sequential 5-minute periods with the seepage switched on and off. Experiments were also conducted by visiting students from Delft Technical University and University of Paris, particularly related to growth of bedforms. They found that ripple growth rate was reduced when the bed was under the influence of seepage. They concluded that infiltration caused a small reduction in the sediment transport rates, but they were unsure whether it was a significant reduction. However, they found no measurable effect of seepage on the reference concentration and mixing length using the suction samplers, but this may have been due to the lack of concentration measurements near the bed.

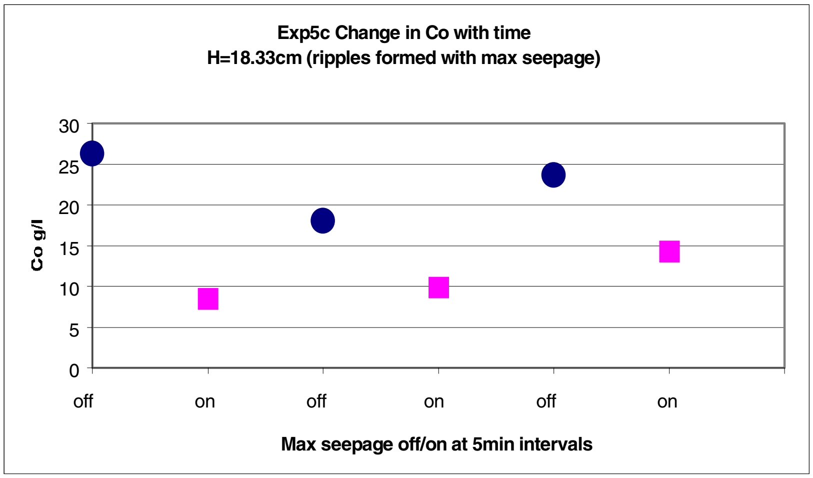

Figure 4 Changes in the near-bed suspended sand concentration C0 with time as the infiltration is switched on and off at five minute intervals.

IMPACT/APPLICATION

Small-scale sediment processes are integral to understanding many engineering applications involving dynamics near the seabed. We believe the results from the collaborations described above are essential for the development of process-based, predictive models that can accurately describe sediment transport and the morphodynamic evolution of coasts.

TRANSITIONS

None

RELATED PROJECTS

Each of the co-Principal Investigators have ongoing related research projects.

PUBLICATIONS

D M Hanes, V Alymov, E D Thosteson, Y Chang, C E Vincent. (1998) Local Seabed Morphology and Small Scale Sedimentation Processes During SANDYDUCK97. EOS (abstract only).

C E Vincent, K Black, D M Hanes (1998) Fine-scale resuspension processes by waves over flat and rippled beds: field observations. EOS (abstract only).

S.R. McLean, J.S. Ribberink, C.M. Dohmen-Janssen and W.N.Hassan (in press) Sediment Transport Measurements within the Sheet Flow Layer Under Waves and Currents. J of Waterways, Ports, Coastal and Ocean Engineering, ASCE.

K.P. Black and C.E. Vincent. Sediment suspension under shoaling waves: high-resolution field measurements and numerical models. (submitted to Coastal Engineering)
Ribberink, J.S., C.M. Dohmen-Janssen, D.M. Hanes, S.R. McLean, J.A. Taylor and C. Vincent (1999) Near-bed sand transport mechanisms under waves: large-scale flume experiments. Accepted for 27th Int. Conf. on Coast. Eng.(ICCE 2000), ASCE, Sydney.

COLLABORATION

Dates	Personnel	Activity
1 Nov – 12 Dec 1998	Charlotte Obrai and Dr Mike Webb (UEA) to work with Dr Peter Nielsen (Brisbane)	Measurements of suspended sediment concentration during percolation
10 – 24 Nov 1998	Wael Hassan (UT) to UCSB to work with Dr Steve McLean	processing of sheet flow data, measured in the large oscillating water tunnel.
Jan – May 1999	Peggy Oliva (U Paris), Mark Caljouw and Michiel van Goor (Delft Univ of Tech) to Brisbane to work with Dr Peter Nielsen	Studies of bedforms on ventilated/ unventilated beaches. Formation of scarps on beaches
2 – 7 March 1999	Dr Steve McLean (UCSB) to UT to work with Marjolein Dohmen-Janssen and Dr Jan Ribberink	preparation UT/UCSB-contribution to SISTEX99
4 – 5 March 1999	Dr Jan Ribberink and Marjolein Dohmen-Janssen (UT), Dr Steve McLean (UCSB), Dr Dan Hanes (UF), Dr Jon Taylor (UEA), Gert Klopman (AFR), Allistair Arnott (Uedin): visit to Hannover	kick-off meeting SISTEX99 / confer with Franzius Institute (Dr Andreas Matheja) and GWK (Dr Joachim Grune)
19 Apr – 24 May 1999	Dr Steve McLean (UCSB) to UT to work with Marjolein Dohmen-Janssen and Dr Jan Ribberink	preparation UT/UCSB-contribution to SISTEX99 and extending processing software
May – September 1999	Jan Ribberink, Marjolein Dohmen-Janssen, Marieke Vuurboom (UT), Steve McLean, Tim Maddux (USCB), Dan Hanes, Vadim Alymov, Beth Cranston, Yeon Sihk Chang (UF)**,** Chris Vincent, Jon Taylor, Charlie Obhrai (UEA), Gert Klopman (AFR), Theo Westgeest (DUT), Peter Thorne (POL), Leo van Rijn, Bart Grasmeijer (UU)	SISTEX99 at the Grosse Wellen Kanal, Hannover
4 Sept 1999	Dr Jan Ribberink and Marjolein Dohmen-Janssen (UT), Dr Dan Hanes and Yeon Sihk Chang (UF), Dr Chris Vincent (UEA), Dr Steve McLean and Tim Maddux (UCSB), Dr Alex Khabadov and (IWEP)	Workshop and Progress Meeting Genova

FUTURE COLLABORATIONS

- Collaborations with different partners of SISTEX99 (UT, UCSB, UF, UEA, DUT) on processing, analysis and intercomparison of the data, including visit of Marjolein Dohmen-Janssen to UCSB and to UF, and a SISTEX99-workshop (April 2000).
- UF (Dan Hanes) will be collaboration with UT on sheet flow modeling.
- Participation of NICOP partners in the EC MAST project SEDMOC workshop (Trondheim, April 2000).